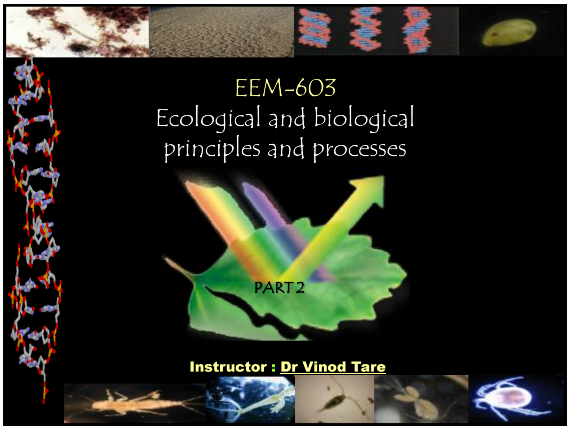


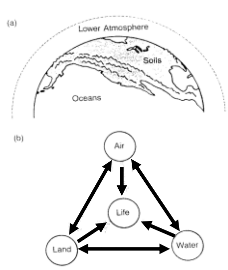
Life on the Planet Earth

Earth as a planet has been profoundly altered by life. Earth's air, oceans, soils, sedimentary rocks are very different from what they would be on a lifeless planet. In some ways, life controls the makeup of the air, oceans, and sediments. It has greatly changed Earth's surface during the last 3 billion years and continues to control and modify

Biosphere

- It is the region of earth where life exists. It extends from the depths of ocean to the summit of mountains, but most life exists within a few meters of Earth's surface. The biosphere includes all of life, the lower atmosphere, and the oceans, rivers, lakes, soils, and solid sediments that are in active interchange of materials with life.
- *All living things require energy and materials. In the Biosphere, energy is received from the sun and the interior of Earth, and is used and given off while materials are recycled.*

Life & Land-Water-Air Interaction



The Biosphere is a linked system, all its parts are connected

Ecosystem

- The smallest unit of the Biosphere that can sustain life is called an ecosystem.
- It is a fundamental principle that sustained life on Earth is a characteristic of ecosystems, not of individual organisms or populations or single species.
- The smallest ecosystems that have been known to sustain life over a long period of time are Folsom bottles/tubes.
- The term ecosystem is applied to areas of all sizes, from the smallest puddle of water to a large forest.
- Ecosystems also differ greatly in composition, that is, in the number and kinds of species, in the kinds and relative proportions of non-biological constituents, and in the degree of variation in time and space.
- Ecosystems can be natural or artificial.
  Ecosystems can be natural or managed.

Uniformitarianism

- Earth and its life forms have changed many times, but certain processes necessary to sustain life and a livable environment have occurred throughout much of history.
- The principle that present physical and biological processes that are forming and modifying our Earth can help explain the geologic and evolutionary history of Earth is known as the doctrine of uniformitarianism.
- Simply stated as "the present is the key to the past"
- Uniformitarianism does not demand or even suggest that the magnitude and frequency of natural processes remain constant with time. Obviously, some processes do not extend back through all of geological time.

Uniformitarianism

- To be useful from an environmental standpoint, the doctrine of uniformitarianism will have to be more than a key to the past.
- A study of past and present processes may be key to the future. That is, we can assume that in future the same physical and biological processes will operate, but the rates will vary as the environment is influenced by human activity.

Systems and Changes

- Solutions to environmental problems often involve an understanding of systems and rates of change.
- A system is a set of components or parts functioning together to act as a whole.
- In environmental studies, at every level, we deal with complex systems; thus it is important to understand certain basic characteristics of every system. A single organism is a system. A sewage treatment plant is a system. A city can be a system. Earth is a system.

Systems and Changes

- Systems may be open or closed. A system that is open in regard to some factor exchanges that factor with other systems. A system that is closed in regard to some factor does not exchange that factor with other systems.
- Systems respond to inputs and have outputs. Our body, for example, is a complex system. If we see a snake in this classroom, the sight of the snake is an input. Our body reacts to that input – the adrenalin level in our blood goes up, our heart rate increases, and so on. Our response, perhaps moving away or arresting/killing the snake – is an output.

Feedback

- It is a special kind of response. Occurs when the output also serves as an input and leads to changes in the state of the system.
- Negative feedback: Systems response in the opposite direction to the output. Example: Regulation of Body Temperature – Physiological and Behavioral.
- Positive feedback: An increase in output leads to a further increase in output. Example: Fire in a forest.
- Negative feedback is generally desirable because it is stabilizing – it leads to a system that remains in a constant condition.
- Positive feedback is destabilizing. A serious situation can occur when our use of the environment leads to a positive feedback.

Environmental Unity

Environmental Unity means that it is impossible to do only one thing; that is, everything affects everything else. Many aspects of environment are closely related. Disruptions or changes in one part of the system will often have secondary and tertiary effects within the systems or will even affect adjacent system. Earth and its ecosystems are complex entities in which any action has several or many effects.

Exponential Growth

A particularly important example of positive feedback occurs in the exponential growth of population; in such growth the increase is at a constant rate of the current amount.

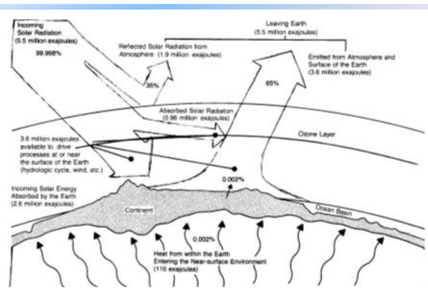
Changes in the system

- Changes in natural systems may be predictable and should be recognized by anyone looking for solutions to environmental problems.
- By using rates of change or input/output analysis of systems, we can derive an average residence time for such factors. The average residence time is a measure of the time it takes for the total stock or supply of a particular material, such as a resource, to be cycled through the pool.

Understanding of Changes in Systems

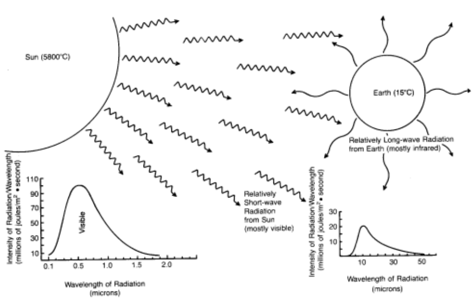
- An understanding of changes in systems is primary in many problems in environmental studies.
- In some cases, very small growth rates may yield incredibly large numbers in modest periods of time.
- It may be possible to compute an average residence time for a particular resource and use this information to develop sound management principles.
- Recognition of positive and negative feedback in systems, and calculation of growth rates and residence times, enable predictions concerning resource management.
- It is important to understand the ways in which physical and biological processes, with or without human interference, may modify ecosystems and Earth.

Earth as Annual Energy Budget



Annual energy flow to earth from the Sun and the relatively small component of heat from Earth's interior to the near surface environment.

Emission of energy from the Sun Compared with that from Earth



Changes Near Earth Surface

Throughout the nearly five billion years of Earth's history, the materials at or near its surface have been more or less continuously created, maintained, and destroyed by numerous physical, chemical, and biological processes.

Collectively, the processes responsible for the formation and destruction of earth materials are referred to as **Geologic Cycles**, which is actually a group of subcycles: the tectonic cycle, the hydrologic cycle, the biogeochemical cycles, and the rock cycle.

The Geologic Sub-Cycles

The **tectonic cycle** is driven by forces originating deep within Earth. It deforms Earth's crust, producing external forms such as ocean basins, continents, and mountains. The Earth's outer layer, containing the continents and oceans is about 100 km thick. This layer, known as the lithosphere, is broken into several large segments called plates, which are moving relative to one another.

The Geologic Sub-Cycles

- The **Hydrologic Cycle** is driven by solar energy, encompasses the movement of water from the oceans to the atmosphere and back to the oceans by way of evaporation, runoff from streams and rivers, and groundwater flow.

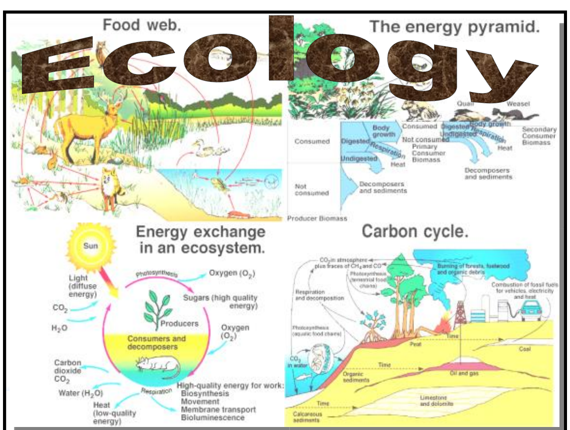
- The **Biogeochemical Cycle** is the cycling of chemical element through Earth's atmosphere, oceans, sediments, and lithosphere as it is affected by the geological and biological cycles. It can be described as a series of compartments, or storage reservoirs, and pathways between these reservoirs.

The Geologic Sub-Cycles

- Of the elements that circulate in the biogeochemical cycles, many are required for life and can be divided into three groups:
  1. The "big six" that form the major building blocks of organic compounds: carbon, hydrogen, oxygen, nitrogen, phosphorous, and sulphur;
  2. The "macronutrients" required in large amounts by most forms of life and includes elements like sodium, potassium, calcium, iron, magnesium, etc.
  3. The "micronutrients" required in very small amounts by at least some organisms such as boron used by green plants, copper used in some enzymes, and molybdenum used by nitrogen fixing bacteria.
- The **Rock Cycle**, the largest of the Earth cycles, consists of a group of processes that produce rocks and soil. The rock cycle depends on the tectonic cycle for energy, the hydrologic cycle for water, and the biogeochemical cycle for materials.

Summary

- Sustained life is a characteristic of an ecosystem, the smallest unit of the biosphere with inputs, outputs, and cycles necessary to keep life going.
- Present natural processes are the same as those of the past and will continue into the future. Human activity influences the rates at which these processes operate.
- All natural systems involve feedback. Negative feedback is stabilizing; positive feedback is destabilizing.
- Systems involve cycles; subcycles of the geologic cycle include the tectonic cycle, the hydrologic cycle, the biogeochemical cycles, and the rock cycle.
- The ultimate fate of every species is extinction. Human activities increase or decrease the time required for extinction to occur for any species, including its own.



Ecology

- The body of knowledge concerning the economy of nature – the investigation of the total relations of organisms both to its inorganic and organic environment; including above all, its friendly and inimical relation with other organisms with which it comes directly or indirectly into contact.

- Other definitions: "Scientific natural history" ; "Sociology and economics of animals"; "The Science of the Community"; "The science of the environment"; "The study of the structure and function of nature"

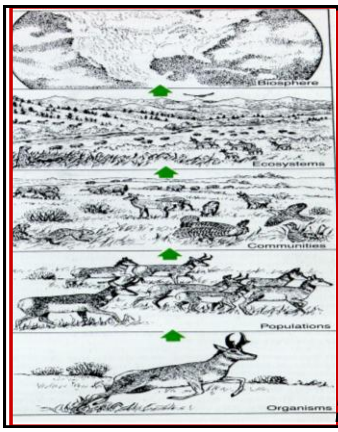
Ecology

- Ecology concerns itself with the interrelationships of living organisms, plant or animal, and their environments; these are studied with a view to discovering the principles which govern the relationship.
- That such principles exist is a basic assumption – and an act of faith – of the ecologists
- The substance of ecology is found in the multitude of abiotic and biotic structures, processes, and interrelations involved in moving energy and nutrients and in regulating population and community structure and dynamics.

Ecosystems

- An ecosystem is a system formed by the interactions of a variety of individual organisms with each other and with their physical environment. Ecosystems are nearly self contained so that the exchange of nutrients within the system is much greater than exchanges with other systems.
- An ecosystem consists of a community of organisms and its local nonliving environment. Thus an ecosystem is not entirely biological entity and hence any complete description of an ecosystem must include the physical environment as well as the biological components, and the interactions between the two.

Part 2 EEM 603A Ecological and Biological Principles and Processes Dr Vinod Tare



- Galaxies
- Universe
- Earth, Planets, Stars
- Biosphere
- Ecosystems
- Communities
- Populations
- Organisms
- Organ Systems
- Organs
- Tissues
- Cells
- Compounds
- Molecules
- Atomic

The Nature of Ecosystem

- **Ecosystem has several fundamental characteristics**
  - An Ecosystem has Structure - Non Living and Living Part
  - An Ecosystem has Processes: Energy Flow & Chemical Elements' Cycling
  - An Ecosystem Changes Over Time, through a Process called Succession

Part 2 EEM 603A Ecological and Biological Principles and Processes Dr Vinod Tare

Components of Ecosystem

- **The biological or biotic component:**
  - This includes both living organisms and products of these organisms. Thus all bacteria, fungi, plants, and animals are included, as well as waste products of these organisms such as fallen leaves and branches from plants and feces and urine from animals. In addition, when an organism dies, it generally remains within the ecosystem, and the body or stalk or trunk remains as a part of the system.
- **The abiotic component:**
  - The nonbiological or physical portions of an ecosystem are called the abiotic components. The biological world lives within and depends on the abiotic environment.

The interrelationships between the biotic and abiotic are so intimate that living and nonliving systems must be studied simultaneously.

Part 2 EEM 603A Ecological and Biological Principles and Processes Dr Vinod Tare

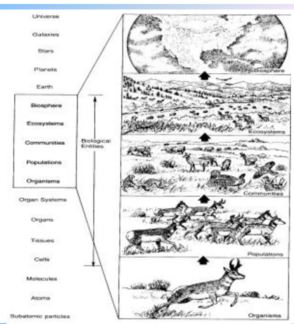
Factors Contributing to the Abiotic Environment

- **Sunlight**
- **Nutrients**
- **Air**
- **Soil**
- **Water**
- **Climate**

Part 2 EEM 603A Ecological and Biological Principles and Processes Dr Vinod Tare

Life: Hierarchy of Entities

Life involves a hierarchy of entities, from cells through organisms; and form organism to population, communities, ecosystem, and biosphere; these in turn lie between other hierarchy; From molecules down to subatomic particles and from earth to universe



Sunlight

- Organisms are bound by the constraints of thermodynamics and need a continuous supply of energy to survive. The source of energy in nearly all ecosystems is the sun. Some of the energy in sunlight is absorbed within the green leaves of plants and used in the bio manufacture of complex, energy-rich materials such as sugars. In turn, sugars and other related compounds are used as a primary fuel source by the plants and animals that eat them. The Sun also provides the energy to warm the Earth. Without the Sun, temperatures would approach absolute zero, there would be few gases or liquids, and there would not be enough thermal energy to initiate the complex reactions necessary for life.

Nutrient

- Organisms are made up of matter and need a constant supply of chemical nutrients to grow, to reproduce, and to regulate bodily functions. The main components of living tissues are carbon, hydrogen, oxygen, nitrogen, phosphorous, and sulphur, but a large variety of other nutrients are also required. Nutrients are found in the air, soil, and water.

Air

- The atmosphere is composed mainly of molecules of nitrogen and oxygen, with smaller concentrations of carbon dioxide, water vapour, and other gases. The existence of an atmosphere on Earth and the presence of specific gases can be explained by abiological laws. However, the composition of the Earth's atmosphere is not easily explained by abiological laws. Thus it is believed that living organisms may have been active agents in the evolution of the modern atmosphere.

Soil

- Soil is composed partly of finely ground rock and minerals. True soil contains minerals mixed with large quantities of partially decayed plant and animal matter. The organic material serves many functions. It provides nutrients that can be reused and recycled by plants. Organic matter also changes the physical nature of ground rock so that it retains moisture more effectively. In addition, the roots of living plants hold the soil together and prevent erosion due to rains and wind storms.

- A single kg of fertile soil in a temperate ecosystem may house 2 trillion bacteria, 400 million fungi, 50 million algae, and 30 million protozoa as well as thousands of worms, insects, and mites. All these organisms are an integral part of the process of decay and recycling that are essential to the growth of the plants and animals that live on the surface.

Water and Climate

- **Water**
  - Is formed by a great number of different kinds of chemical reactions.
- **Climate**
  - The combinations of temperature and moisture in an area are the important factors that establish the climate, the yearly cycle of weather patterns. Climate, in turn, affects the characteristics of an ecosystem.

Many other factors combine to create the abiotic environment. The salinity of a bay where rivers and ocean meet, the turbulence of water at a seashore, or the amount of wind on a mountaintop, all contribute to the physical environment to which organisms must adapt

The Biological or the Biotic Component
(The Living Part is the Community)

- Producers and Production
  - **Photosynthesis:** Plants are fundamental to all life on Earth because they have the ability to tap some of the solar energy that strikes their leaves and needles and to use this energy to build living tissues. This process, known as photosynthesis, is expressed by the following equation:

    Carbon dioxide and Water in presence of sunlight gives Sugar and Oxygen

  - During photosynthesis, the inorganics, energy – poor molecules, carbon-di -oxide and water, are converted into organic, energy - rich food molecule such as sugars.
  - Since plants do not need to feed on other organisms, they are called **autotrophs,** meanings "self-nourishers". Animals can not use the Sun in this manner; they are therefore dependent on plants, directly or indirectly, as their fundamental source of food.

The Biological or the Biotic Component
(The Living Part is the Community)

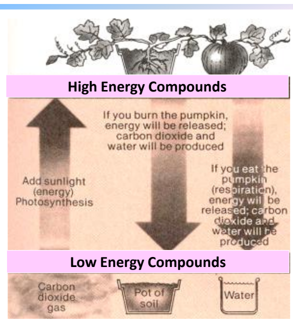
- **Respiration:**
  - The energy trapped by the plant during photosynthesis is not lost, Sugar, the product of photosynthesis, contains stored chemical energy and can be burned to produce heat and hence do some work.

    Sugar in presence of Oxygen burns to produce Carbon di oxide, Water and Energy

  - Sugar combines with oxygen inside living cells to produce the same products in the same proportions. The difference is that in a living organism, the oxidation proceeds at a slower and more controlled rate. This process, known as respiration, releases the energy stored in complex molecules for use in maintaining cell functions.
  - Plants engage in both photosynthesis and respiration. Sugars are produced by photosynthesis. The sugars are then used as a source of chemical energy, which is released during respiration within the leaf tissues. The energy is then used to build other complex molecules to maintain cell functions.

Flow of Energy and Materials

Some energy Relationship of a Pumpkin Plant



Consumers and Consumption

- Several organisms (like animals, humans, etc.) can not make their own food but must eat other organisms or their products to obtain energy-rich molecules needed for survival. Therefore they are consumers. Consumers are called heterotrophs, referring to organisms that are nourished from other sources.
- **Heterotrophs** can be further divided into two large categories. Herbivores are animals that eat plants. Carnivores are animals that eat the flesh of other animals. Carnivores can be large, like a tiger, or small, like a ladybug, or even tiny, like a microscopic amoeba.

A few insect-catching plants are both producers and consumers, and many animals, such as pigs, bears, rats, and humans, are omnivores, animals that eat both plants and animals.

Consumers and Consumption

- Scavengers are animals that eat dead plant and animal matter. Thus, a vulture is a scavenger because it eats dead animals, and a termite is part of the same classification because it feeds dead and decaying wood.
- The distinction between a scavenger and a herbivore or carnivore is not always clear in nature.
- **Decomposers:** Because plants can manufacture their own food, it would seem at first glance that an ecosystem could survive indefinitely if it contained only plants. But this is not the case. Plants remove minerals from the soil, and soil minerals are replaced only very slowly from the rock beneath. In an agricultural system, nutrients are often replaced artificially by fertilization. In a natural system, if plants just went on living and growing and dying, eventually all the minerals in the ecosystem would be absorbed into the body plants containing minerals but no more minerals in the soil, and plant growth would stop. Therefore, every ecosystem needs, and contains, **decomposers**.

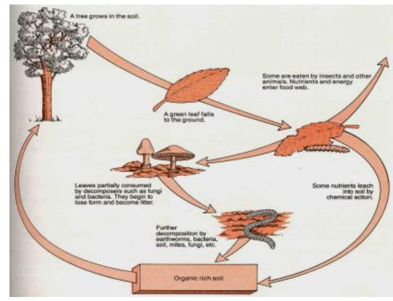
Consumers and Consumption

- Heterotrophic organisms that feed solely on dead organic matter are called **saprophytes**.
- The bulk of the saprophytic decomposition is carried out by bacteria, fungi, and protozoa. Imagine that a piece of organic litter falls to the floor of a forest. In a typical sequence, microscopic bacteria or fungi will excrete chemicals, called **enzymes**, that break down complex chemical compounds in the object. Some of the breakdown products are absorbed as food, whereas others are left behind. These serve as a food supply for other organisms that carry the decomposition one step further. Eventually, the waste products of the final line of decomposers are energy-poor mineral nutrients that are reabsorbed, and thus recycled, by plants.

Food Chains and Food Web

- One way individuals in a community interact is by feeding on one another. Energy, chemical elements and some compounds are thus transferred from creature to creature along what is called as food chains. In more complex cases food chains are also referred as food webs. Ecologists group the organisms in a food web into trophic levels.

Flow of Energy and Materials



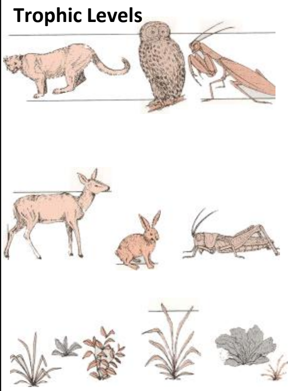
Trophic Levels

- A trophic level describes how far an organism is removed from plants in its nourishment or in other words it consists of all those organisms that are the same number of feeding levels away from the original source of energy.
- The original source of energy in most ecosystems is the sun. Green plants can make food by directly interacting with sunlight, so they are grouped into what is called the first trophic level.
- Herbivores, which feed on plants, are members of the second trophic level. For example, grasshopper that eats grass belongs to the second trophic level.
- Carnivores that feed directly herbivores are in the third trophic level. For example, a shrew that eats the grasshopper belongs to the third trophic level.

Trophic Levels

- Carnivores feeding on third-level carnivores are in the fourth trophic level; and so on. For example, an owl that eats the shrew belongs to the fourth trophic level, and so on.
- In another commonly used set of norms, plants are said to be **producers**, herbivores are **primary consumers**, and carnivores are **secondary**, **tertiary**, and **quaternary consumers**, depending on what they eat.
- Omnivores, which eat both producers and consumers, belong to many trophic levels

Trophic Levels



Predators

Third Trophic Level (or higher) | Secondary Consumers (or higher)

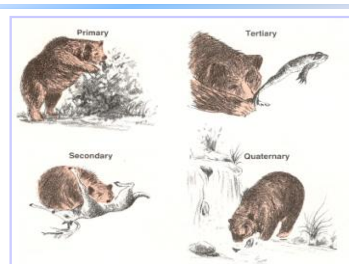
Grazers

Second Trophic Level | Primary Consumers

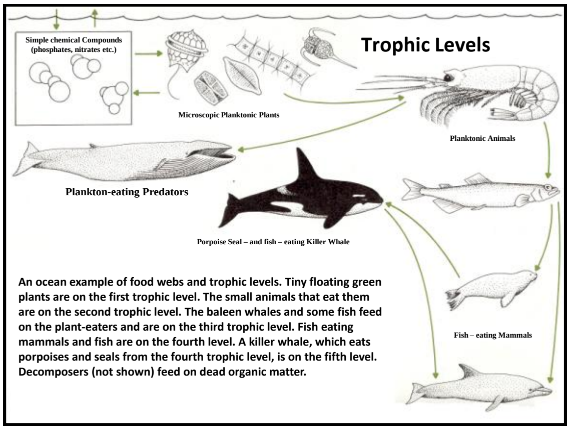
Plants

First Trophic Level | Producers

Trophic Levels



The bear, an omnivore, consumes organisms from various trophic levels in the food chain, acting as a primary, secondary, tertiary and quaternary consumer

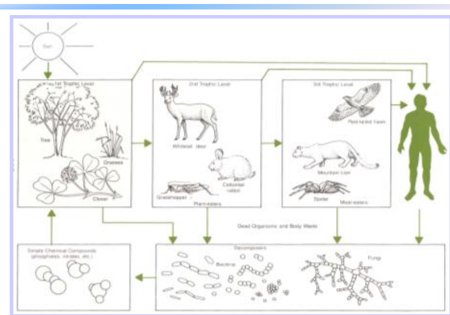


An ocean example of food webs and trophic levels. Tiny floating green plants are on the first trophic level. The small animals that eat them are on the second trophic level. The baleen whales and some fish feed on the plant-eaters and are on the third trophic level. Fish eating mammals and fish are on the fourth level. A killer whale, which eats porpoises and seals from the fourth trophic level, is on the fifth level. Decomposers (not shown) feed on dead organic matter.

Trophic Levels

In north temperate woodlands, the first trophic level includes trees and- in fields – grasses and herbs. The green plants are fed on by deer, grasshoppers, and rabbits, which are on the second trophic level. Predators of these, such as the mountain lion, hawks, and spiders, are on the third trophic level. Human beings eat plants and animals from many trophic levels. Dead organisms are eaten by decomposers, and the simple chemical compounds returned to the soil to be used by the green plants. Decomposers, most of which can feed on many kinds on dead tissue, are usually separated as shown in the trophic scheme. These diagrams are greatly simplified. In reality; many organisms feed on several different trophic levels, as shown in following figure…

Trophic Levels



The Ecological Niche and Habitat

- Each species performs unique functions and occupies specific habitats. An organism's **habitat** is its address, the place where it lives. The **ecological niche** is a description of an organism's habitat – its physical location within an ecosystem – plus its functions in the patterns of energy flow and nutrient cycling.
- Where an organism lives is its habitat; what it does is its niche.
- Thus, a niche can be considered to be analogous to a human profession, the way in which an organism makes a living.
- A niche includes all of an organism's interactions with the physical environment and with other organisms that share its habitat.
- To describe a niche, one would have to describe all physical characteristics of a species' home. One might start with specifying the gross location (e.g. mountains or the ocean floor) and the type of living quarter (e.g. a burrow under the roots of trees). For plants and less mobile animals, preferred microenvironment, such as the water salinity, soil acidity, or the necessary turbulence.

The Ecological Niche and Habitat

- An animal's trophic level and a description of the organisms that it feeds upon are also part of niche. Similarly, the predators and competitors that an organism must contend with are part of its place and function in an ecosystem.
- Mobile animals generally have a more or less clearly defined food-gathering territory, or home range, which is another factor in establishing the physical niche.
- A niche is not an inherent property of a species, because it is governed by factors other than genetic ones. Social and environmental factors also play a part in establishing the niche.
- The niche of a given species in a given ecosystem is not a set of conditions that would be best suited to the genetic makeup of the organism, but rather, it is the set of conditions in which it actually survives.

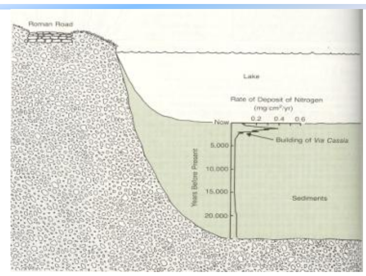
The Ecological Niche and Habitat

- The niche of a species can be determined by finding out all of the environmental conditions under which it persists. The set of conditions under which it can persist without competition from other species is called its fundamental niche while the set of conditions under which it persists in the presence of natural competitors is called its realized niche.

The Human Intervention in Ecosystems

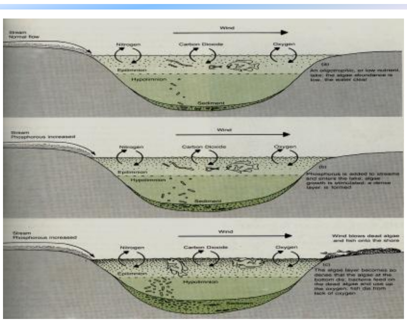
- Through Developmental Projects
- Through Disposal of Wastes
- Through Control Measures

Through Developmental Projects



The effect of Roman road building about 2000 years ago is seen in the lake sediments of Lago di Monterosi. Eroded soil entered the lake, increasing the growth of algae and the rate of sediment deposition. One change that occurred was increased nitrogen deposition in the sediments

Through Disposal of Wastes



Phosphorous as a Limiting Nutrient

Aerial photograph of a lake divided into parts by a large plastic sheet. The Canadian Freshwater Institute added chemical elements to one side only. The results of this experiment demonstrated that phosphorous produced algae blooms and was an important limiting nutrient

The Human Intervention in Ecosystems - Through Control Measures

Ecologists Lamont Cole investigated one such situation in the 1950s

- WHO recommendations in Borneo for malaria control
- Quantities of DDT consumed by cockroaches
- Geckos on cockroaches
- Geckos by cats
- Rats moved to cities with rat fleas
- Caterpillars eating thatched roofs ?
- Stopped spraying DDT & parachuted a large number of cats in to the jungles

Ecosystem Processes: Energy Flow, Biomass and Ecological Production

- Energy Flow and Biomass
  - All life requires energy.
  - Energy is the ability to do work, to move matter.
  - Organism’s weight is a delicate balance between the energy taken and the energy used. Energy not used and not passed on is stored.
  - Use of energy, and gain or loss of weight by an organism follows the laws of physics.
  - This appears very simple. But this is one of the most philosophical aspects of environmental studies.
  - Consideration of the role of energy in an ecosystem is the heart of the matter that distinguishes life and life-containing systems from the rest of the universe.
  - Organic matter is called the **Biomass**.

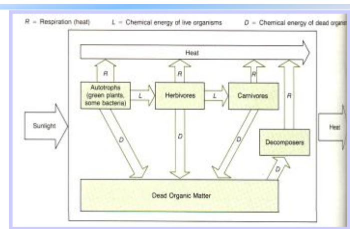
Ecosystem Processes:
Energy Flow, Biomass and Ecological Production

- Energy Flow and Biomass
  - **Ecological Production** is the change in organic matter or biomass. Because there is close relationship between the amount of organic matter and amount of stored energy, ecological production can be measured both ways – as amounts of matter (e.g. tones per square meter) or as energy (e.g. calories per square meter).
  - Energy enters an ecosystem, is used, stored, and eventually given off. Matter and energy are both subject to laws of conservation:

    # In any physical or chemical change, matter is neither created nor destroyed, but merely changed from one form to another.

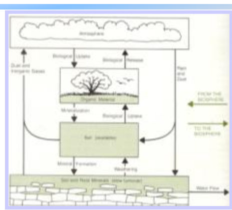
    # In any physical or chemical process, energy is neither created nor destroyed, but merely changed from one form to another (**First Law of Thermodynamics**).

Flow of Energy



Energy flows through an ecosystem, chemical elements cycle. (a) The pathway of usable energy is from an external source through the ecosystem's food chain, and to an external sink as heat energy. Some stored energy may be cycled temporarily in the chemical bonds of compounds that are transferred from one organism to another, but the predominant flow is one way. At each trophic level, some energy is released as heat by respiration (R), some is transferred to the next trophic level (L) and some is transferred to the decomposers through death and excrement (D).

Flow of Materials

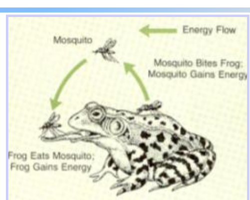


Generalized ecosystem mineral cycling. Chemical element cycle *within* an ecosystem and are exchanged between an ecosystem and the biosphere. Organisms exchange elements with the nonliving environment; some elements some are taken up from and released to the atmosphere, while other are exchanged with water and soil or sediments. The parts of ecosystem can be thought of as storage pools for an element. The elements move among pools at different transfer rates and remain within different pools for different average lengths of time called residence times. For example, the soil in a forest has an active part, which rapidly exchanges elements with living organisms, and an inactive part, which exchanges elements slowly. Generally, life benefits if the elements are kept within the ecosystem and are not lost by erosional processes.

Energy Conservation and Perpetual Motion Machine

- If energy is always conserved, why can't organisms recycle energy inside the body? And similarly, why can't energy be recycled in ecosystems and in biosphere?
- Can we have a Biological Perpetual motion machine ?

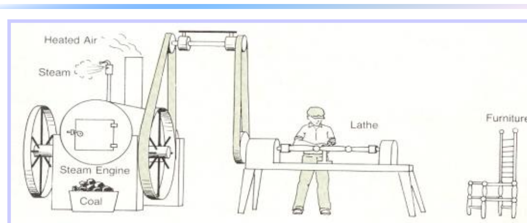
Energy Conservation and Perpetual Motion Machine



An impossible ecosystem: Frogs and mosquitoes, and nothing else. Frogs eat insects, such as mosquitoes. Mosquitoes also feed on the blood of frogs. Why is it not possible to have an ecosystem made up only of frogs and mosquitoes, each feeding on the other?

….. The laws of thermodynamics tell us that such a biological perpetual motion machine is impossible.

Energy Conservation and Perpetual Motion Machine

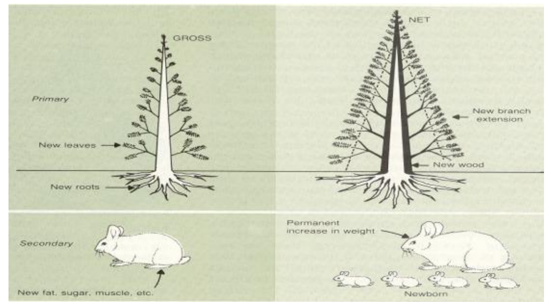


An imaginary closed thermodynamic system, with a steam engine running a lathe. An engineer puts coal and water into the engine, which runs the lathe to make furniture. When the coal has all burned, the energy it contained is dispersed as heat throughout the system

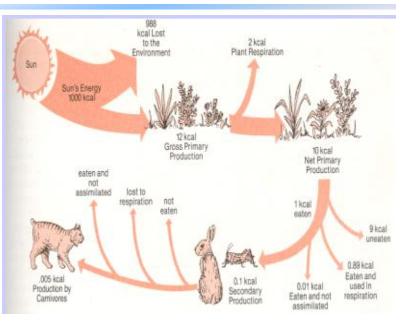
Life means Destabilization

- The general answer as to why this system would not persist lies with the **Second Law of Thermodynamics**, which addresses the kind of change in form that energy undergoes.
  - Energy always changes from a more useful, more highly organized form to a less useful, disorganized form. Energy can not be completely recycled to its original state of organized, high-quality usefulness.
  - The energy is degraded and the system is said to have undergone a decrease in order. The measure of the decrease in order (the disorganization of energy) is called entropy
- **The Basic Quality of Life:**
  - It is the ability to create order in local scale that distinguishes life from its non-living environment.
  - Obtaining this ability requires energy in a usable from, and this is essence of what we eat and why there can't be life without the Sun.

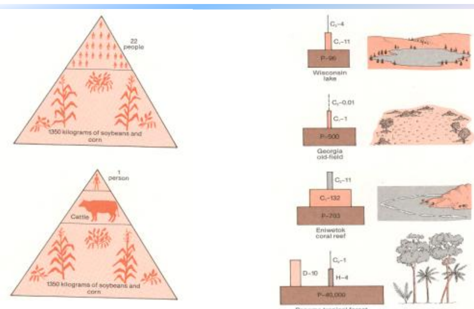
Ecological Production



Energy Capture/Loss at Various Trophic Levels



Energy Capture/Loss at Various Trophic Levels



Gross and Net Primary Productivity

- The **Gross Primary Productivity** of an ecosystem is the rate at which organic matter is produced during photosynthesis.
- Gross primary productivity is often expressed in terms of Kilocalories of chemical energy stored per square meter per year (kcal/m^2/yr). Alternatively, productivity can be expressed in terms of grams of material produced per square meter per year (g/m^2/yr).
- Only about half the gross productivity accumulates as new plant matter, because the rest of chemical energy is metabolized by the plants own respiration and released to the environment as heat.
- The net gain in plant matter is called **Net Primary Productivity.** The net primary productivity appears as plant growth and is available for consumption by heterotrophs

Gross and Net Primary Productivity

- **Net Primary Productivity = Gross Primary Productivity – Plant respiration**
- Productivity depends on a verity of factors such as sunlight, temperature, rainfall, and the availability of nutrients. For example the net primary productivity of a trophical rain forest is orders of magnitude greater than that in a desert.
- Some of the plant matter produced is consumed by animals or decomposers, and some accumulates in the environment. The total quantity of organic matter present at any one time in an ecosystem is called the **biomass**. The biomass equals the total organic matter gained through net productivity over a period of time minus the quantity of material that is consumed and lost during respiration by animals.

Net Primary Productivity of Major Ecosystems*		
Type of Ecosystem	Net Primary Productivity; g/(m^2 year)	
	Normal Range	Mean
Trophical Rainforest	1000 – 3500	2200
Trophical Seasonal Forest	1000 – 2500	1600
Temperature evergreen forest	600 – 2500	1300
Temperature deciduous forest	600 – 2500	1200
Boreal forest (taiga)	400-2000	800
Woodland and shurbland	250 – 1200	700
Savanna	200 – 2000	900
Temperature grassland	200 – 1500	600
Tundra and alpine	10 – 400	140
Desert and semidesert scrub	10 – 250	90
Extreme desert, rock, sand and ice	0 – 10	3
Cultivated land	100 – 3500	650
Swamp and mars	800 – 3500	2000
Lake and stream	100 – 1500	250
Open ocean	2 – 400	125
Upwelling zones	400 – 1000	500
Continental shelf	200 – 600	360
Algal beds and reefs	500 – 4000	2500
Estuaries	200 – 3500	1500

Element	Function
Carbon	The primary building block of large organic compounds; forms long chains and combines with many other elements.
Calcium	The beam of girder element, important in strong structures – shells, bones, teeth of animals, and cell walls of plants; also involved in nerve impulse transmission and muscle contraction.
Hydrogen	The lightest element, a constituent of water and of all organic molecules.
Iron	Various functions in enzymes and some respiratory compounds
Magnesium	Along with calcium, has structural functions (e.g. in bones and shells); also important in some electrochemical and catalytic roles
Nitrogen	The protein element occurs in shells protein, genetic compounds, and all chlorophylls; occurs in very large compounds, but also important in small compounds, including nitrate (an oxide of nitrogen) and ammonia; as ammonia and nitrate, can be taken up by green plants from soils as a nitrogen source.
Oxygen	The respiration element, required in aerobic respiration; one of major (or big six) elements of organic compounds and a constituent of water.

Element	Function
Phosphorus	The energy element, important in energy transfer as the compounds ATP and ADP; also a constituent of nucleic acid; along with calcium and magnesium, important in vertebrate teeth and bones and in some shells of invertebrate
Potassium	Required for certain enzymes; important in nerve cell transmission
Sodium	Essential to animals but not to most plants; important in nerve impulse transmission and in the salt balance of vertebrate blood
Sulfur	Required for many proteins; an essential constituent of some enzymes

Summary

- An ecological community is a set of interacting populations of different species: an ecological system is an ecological community and its local, nonliving environment.
- Sustained life on earth is a characteristic of ecosystems, not of individual organisms, populations, or species.
- The ecosystem concept is at the heart of the management of natural resources.
- The ecosystem must lie between an energy source and an energy sink; these comprise a thermodynamic system. An ecosystem must be an open system with respect to energy; the net flow of energy is one way through the ecosystem.
- A community contains food webs, which can be viewed as a diagram of who feeds on whom.

Summary

- A community can also be divided into trophic levels. A trophic level consists of all the organisms which are same number of food web steps away from the original source of energy.
- A basic quality of life is its ability to create order on a local scale; this is one quality that distinguishes life from its nonliving environment.
- Biomass is the quantity of organic matter; ecological production is the change in organic matter.
- Respiration is the process by which organisms use energy. Gross production is the production of new organic matter before any is used. Net production is the net amount remaining after use.

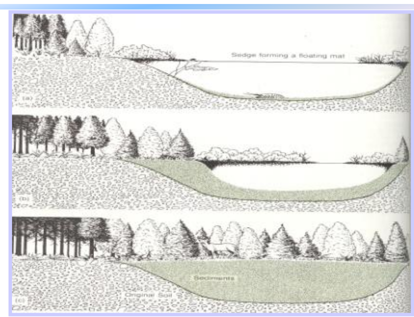
Summary

- Autotrophs produce their own food from energy and inorganic material; this is called primary production. Hetrotrophs feed on other organisms; their new organic matter is called secondary production.
- Every individual requires a number of chemical elements, and these must be available in their right forms, at the right times, and in the right ratios to one another.
- Chemical elements cycle within ecosystems; in theory the cycling could be complete but in reality there is some loss. However, many biological processes tend to conserve chemical elements within the ecosystem.

Ecosystem and Community Patterns
Succession

- Change with time.
- Undergoing patterns of development called **Ecological Succession**.
- Primary Succession: the initial establishment and development of an ecosystem → Forest that develops at the edge of a retreating glacier or on a new lava flow near a volcano.
- Secondary Succession: the reestablishment of an ecosystem → A forest that grows after a hurricane, flood, fire or clearcutting → remnants of the previous biological community are present → such as organic matter and seeds in the soil of a forest.
- Forest Succession; Pond and Bog Succession; Sand Dune Succession

Ecological Succession



Ecosystems and Communities:
Biological Properties

Diversity

There are somewhere between 3 and 30 million species on Earth. That is a great diversity of life

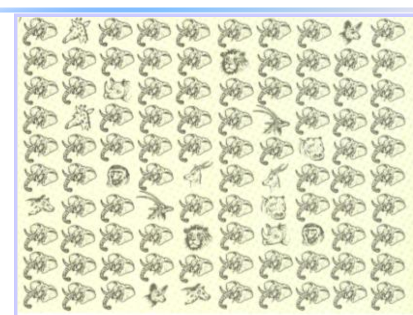
Issues:

- What accounts for diversity in any area or ecosystem ? Or What is biodiversity?
- Does diversity of life tend to increase the likelihood of life's persistence ? Or Importance of Biodiversity!
- How diversity can be maintained ? Or What are the factors which govern biodiversity?

Dominance and Diversity

- Merely counting the number of species is not enough to describe ecological diversity. Diversity has to do with the appearances – the relative chance of seeing species – as much as it has to do with the actual number present.
- Usually a few species are very abundant and the rest are rare. The most abundant species are called **dominant**.

Dominance and Not Diversity



Diversity, Not Dominance

Factors that tend to increase diversity:

- A physically diverse habitat.
- Moderate amounts of disturbance (such as fire or storm in a forest or a sudden storm-flow of water into a pond).
- A small variation in environmental conditions (temperature, precipitation, nutrient supply, etc.) during non disturbance time.
- A high diversity at one trophic level, increasing the diversity at another.
- An environment highly modified by life (for example, a rich organic soil).
- Middle stages of succession.
- Evolution.

Factors that tend to decrease diversity:

- Environmental stress.
- Extreme environments (conditions near to the limit of what living things can withstand)
- A severe limitation in the supply of an essential resource.
- Extreme amounts of disturbance.
- At non-disturbance times, a wide variation in environmental conditions.
- Recent introduction of exotic species (species from other areas).
- Geographical isolation (being on a real or ecological island).

Summary

- In most communities, a few species in each tropical level are very abundant and the rest are uncommon or rare. The very abundant species are called the dominants.
- Within an ecological community, some species play crucial non-replaceable roles. These are called keystone species.
- Species diversity includes two concepts; the number of species present in an area and the relative abundances of the species. The relative abundance is also referred to as the evenness with which the individuals in that area are divided among the species.
- Ecosystems are characterized by change, not constancy.
- Ecosystems and communities develop and change over time, following a sequence called succession.

Summary

- Primary succession is the initial establishment and development of an ecosystem: secondary succession is reestablishment of an ecosystem.
- The final stage of succession was once thought to be a steady state that remain constant unless subject to new disturbance, but we know now that these last stages are also subject to change over time.
- Biomass and species diversity reach a maximum in the middle or late successional stages, and then decrease.
- Succession can be viewed as an interplay between biological and physical process, with the biological processes building up organic matter and the storage of chemical elements, and physical processes eroding and degrading organic matter and chemical elements.

Summary

- If physical processes are too harsh, or disturbance too frequent, succession does not occur.
- Because species have adapted to each successional stage, it may not be desirable to disrupt or halt the successional process.
- For management purposes, we need to think in terms of persistence of ecosystems within acceptable ranges of conditions, resistance to change, ability to recover following disturbance, and recurrence of an ecosystem’s desirable states.

The Ecology of Populations

- Population dynamics
  - Growth Curve
  - Population Cycles
  - Age, Size, and Sex: The structure of Populations
- The Regulation of Population
  - The Logistic and Density Dependent Growth
  - The Balance of Nature and Population Regulation
- Population Interactions
  - The Basic Kind of Interactions between Species
  - Competition
  - Predators, Parasite, and Pray
  - Symbiosis

Population Dynamics

- What controls the growth of populations of living things?
- A **Population** is a group of individuals of the same species living in the same area or interbreeding and sharing genetic information. Or population is the breeding group to which an organism belongs.
- A **species** is all individuals that are capable of interbreeding. A species is made up of populations. *A species is defined as a group of plants or animals that can breed together to produce viable, fertile offspring but cannot do so with members outside the group.*
- Many environmental issues require that we understand the basic concepts of population growth. For example, if a population is endangered, we must try to understand why it is not growing or if a pest population threatens an important resource, a knowledge of population growth may help us find the best way to control the population.
- Individual populations are capable of rapid growth, but this is rarely achieved in nature: control of population is the norm. Although all biological populations have the capacity for exponential growth, few achieve it. Recognition of this leads us to realize that there is competition for survival.

Population Dynamics

- What controls the growth of populations of living things?
- A **Population** is a group of individuals of the same species living in the same area or interbreeding and sharing genetic information. Or population is the breeding group to which an organism belongs.
- A **species** is all individuals that are capable of interbreeding. A species is made up of populations. *A species is defined as a group of plants or animals that can breed together to produce viable, fertile offspring but cannot do so with members outside the group.*
- Many environmental issues require that we understand the basic concepts of population growth. For example, if a population is endangered, we must try to understand why it is not growing or if a pest population threatens an important resource, a knowledge of population growth may help us find the best way to control the population.
- Individual populations are capable of rapid growth, but this is rarely achieved in nature: control of population is the norm. Although all biological populations have the capacity for exponential growth, few achieve it. Recognition of this leads us to realize that there is competition for survival.

Population Dynamics

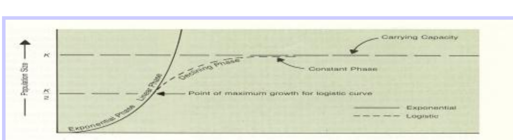
- If no real population can grow exponentially, what kind of growth can one expect ?
- The study of changes in population sizes and causes of these changes is called **population dynamics**.
- Primary Characteristics of a Population: Size (total number of individuals); Birth Rate; Death Rate and Growth Rate.
- Sometimes the interest is in the number of individuals while many times the interest may be in amount of living matter (or organic material contained in living organisms), called biomass.

The Logistic Growth Curve

- A real population generally grows according to an S-shaped curve, called the logistic growth curve. The logistic adds to an exponential growth curve the concept that any real population must be limited eventually by some resource in its environment.
- A **resource** is something an organism requires or uses and obtains from its environment. *This limitation is represented in the simplest possible way by population's **carrying capacity,** which is the maximum population size that can exist in a habitat or ecosystem over long period of time without detrimental effects to either that population or to that habitat or ecosystem.* Detrimental effects are any population effects that would result in decrease in carrying capacity.

The Logistic Growth Curve

- In the logistic growth curve it is assumed that each individual has some negative effect, however small, on the others, either by decreasing the population's reproductive rates or by increasing mortality rates. When a population growing according to the logistic is small, its growth is very close to exponential. At every population level, however, the competition for some resource diminishes the population growth rate.



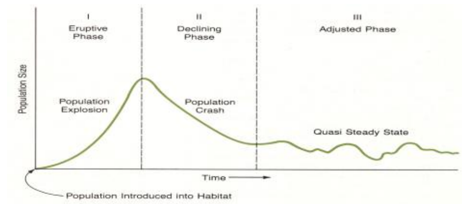
The Logistic Growth Curve

- A logistic population always returns to its carrying capacity (as long as it does not become extinct). This leads to a kind of balance that is called as **stable equilibrium**. The carrying capacity is in equilibrium because when undisturbed, the population remains at this size.

A More Realistic Population Growth Curve

- What accounts for this pattern ?
- The population initially has abundant resources. Births increase rapidly, and the population outstrips the available food supply.
- By the time negative factors take effect, the population is very large, and the impact is dramatic.
- Finally, the population comes into a kind of adjustment with its new environment.
- Having permanently decreased the food supply, it fluctuates in response to changes in climate, changes in food supply, changes in other populations, and other environmental factors.

A More Realistic Population Growth Curve



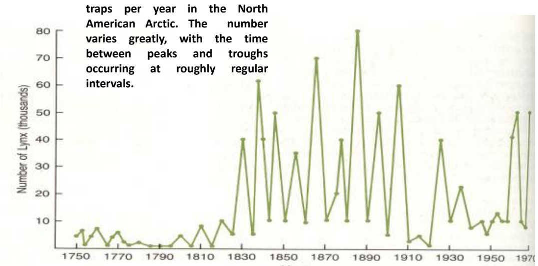
A more realistic population growth curve for a wild population introduced into a new habitat: The population “explodes” because resources greatly exceed requirements (Phase I). Once the population size exceeds resource supply, the population “crashes” (Phase II). Finally, the population reaches an “adjusted phase” (Phase III), where it and its resources vary over time.

Population Cycles

- Some populations vary over time in a way that appears to follow a cycle. In a population cycle, the population increases and decreases in size within a more or less regular time.
- Whether these cycles are very regular, and what causes them, has been a long – standing controversy. If these cycles are natural, then those who want to preserve truly natural populations must allow these fluctuations to continue.
- Such population cycles have been recognized for a wide variety of animals, from salmon to elephants. Evidence suggests that length of a cycle may be related to the average generation time of the species: populations of long-lived animals have stronger cycles than short-lived ones, with the average period of a cycle being four or five times the generation length. The generation length is the time from an individual’s birth to the attainment of reproductive maturity.

Population Cycles

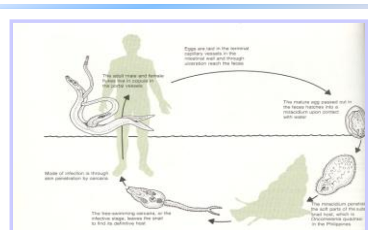
Number of Arctic lynx caught in traps per year in the North American Arctic. The number varies greatly, with the time between peaks and troughs occurring at roughly regular intervals.



The Structure of Populations

- The age structure of a population is the number of individuals of each age in the population. The age structure of a population can have a great effect on birth rates, death rates and growth rates.
- A change in the age structure can alter how a population affects its habitat and how it affects other populations.
- Food requirements, and thus its effects on the food supply, depend on the age structure.
- Ability to resists predators and disease and to survive on its own also depends on the age structure.
- Because the logistic and exponential curves do not take age structure into account, this is another reason why they are inadequate to predict accurately the fate of many populations.
- For most higher organisms there is a stage of immaturity that can make up a large fraction of the life cycle. In addition, some organisms have very complex life cycles, with the young having different habitats than the adults.
- For much of the plant or animal kingdom, however, the stages in the life cycle differ much more from one another. For example, parasites have some of the most complex life cycles, which we must understand if we are to control certain human diseases.

Typical Life Cycles



The complex life cycle of *Schistosoma japonicum,* the parasite that causes schistosomissis a sometimes fatal disease in humans. Many organisms have complex life histories, which make their management, control, or projection a difficult task.

The Regulation of Populations

If a population cannot grow forever, some thing or process must limit the growth. The limitation might be non-biological (a windstorm), or biological but external to a population (a predator or parasite), or due to a process that occurs within the population itself. In the last case, a population might be self-regulating. Most populations are partially limited by many factors at the same time.

Density-Dependent and Density-Independent Population Regulation

- A population that is self-regulating is said to have **density dependent population regulation.** Under density dependent population regulation, the rate of population growth is inversely related to population size: the larger the population, the smaller the growth rate. Density-dependent population regulation implies that there is a feed back; that is, the population in some way responds to its own size or density, bringing about changes in its birth and death rates.
- A population that is not self-regulating may be subject to **density independent population regulation.** In density independent control, the mechanism of control has no relationship to population size. For example, given the death of insects in a forest subject to hurricanes, the population size of insects would have no effect on the frequency or path of hurricanes.
- Moreover, if all the trees were knocked by the hurricane and all the insects were killed, the mortality rate would be 100% regardless of population density.
- Both density dependent and density independent population regulation seem possible in nature. Which is more important? What causes either kind? There has been a long-standing controversy in the study of populations as to the relative importance of these regulatory mechanisms. Density dependent population regulation has been shown to occur for a few species.

The Logistic and Density Dependent Growth

- We can see a connection between density-dependent population growth and the logistic growth curve.
- In a logistic population the growth rate decreases as the population size increases; thus hypothetical logistic population model considers density-dependent regulation.
- This is another reason why the logistic growth model has been so appealing to people who have been interested in conservation and the wise management of our living resources.
- In the management of wild animals and plants, it is often important to know whether there are natural density-dependent population mechanisms. If they exist, managers may be able to use them to achieve their goals. The stronger the natural density-dependent regulation, the less intense must be the control mechanisms by the manager.
- In the past, wildlife has been managed as if density-dependent population regulation existed and could be relied on, often with poor results.

The Balance of Nature and Population Regulation

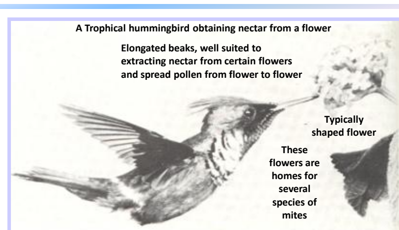
- Density dependent population regulation suggests a world that is well balanced and well controlled – a world where life hums along like a well running automobile engine, responding smoothly to changes in population size. On the other hand, a population that is regulated only by density-independent mechanisms seems destined to undergo abrupt changes in size, to be the slave of unpredictable forces of physical environment.
- Most believe that most of the life was self-regulating. Many people have tended to believe the density dependent regulation despite insufficient evidence. Unfortunately, many failures in the management of our biological resources can be traced, at least in part, to this unjustified assumption.

Population Interactions

- No individual or population exists alone; the essence of sustained life is the interaction of species. It is possible that one population might regulate another, or that two populations, through their interactions, might regulate each other, even if neither could regulate itself. Population interactions therefore could lead to density dependent regulation.
- Populations of different species interact in many ways. The interactions are intricate, elaborate, sometime amazing.

Amazing Interaction Amongst Various Organisms

Interaction among some tropical hummingbirds, flowers, and certain mites

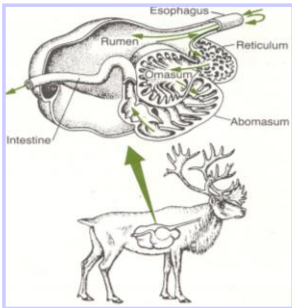


The mites, birds and flowers interact in many ways, some of which are beneficial to several species, some of which are detrimental to one and beneficial to another

The plants compete for pollinators; the pollinating birds compete for nectar; the mites compete among themselves

Amazing Interaction Amongst Various Organisms

The microbes in the stomach of a ruminant (such as a cow, deer, moose, or giraffe) illustrate many kinds of population interactions. Microbes in the rumen digest plant tissue that the mammal cannot digest alone; both benefit from this relationship. The elaborate structures of the ruminant's stomach benefit the animal and its microbes



The Basic Kinds of Interactions Between Species

- An encounter between two individual can be beneficial, harmful, or neutral to either or both of them.
- The sum of many encounters between individuals can be beneficial, harmful, o neutral to the populations to which the individual belongs.
- The effects on the individual are not necessarily the same as they are on populations. For example, if a coyote eats a mouse, it is the end for that mouse, but not for mice.
- Ecology deals mainly with the effects of the sum of individuals encounters on the total community.
- The important encounters between any two individuals, A and B, are those that are potentially beneficial to at least one of them.

Competition

- It is an interaction in which two or more individuals try to gain control on the same resource. There are many different ways in which organisms can compete with each other in nature.
- **Scramble Competition:** occurs when a number of organisms share a limited resource in such a way that no individuals have a particular advantage; therefore, all the individual suffer. Example: Severely limited food supplies equally divided among all the individuals resulting in starvation of everyone.
- **Contest competition:** occurs when one organism harms another in an effort to gain control over a resource. It is easy to observe contest competition. For example when a small bird comes to eat, a large one chases it away. In most cases, there is no physical contact between the birds. The large animal harms the smaller one by chasing it away from its meal, not by physically injuring it.

Competition

- **Intraspecific Competition:** occurs between members of the same species and is therefore very common. Members of the same species generally need the same resources and thus are bound to compete for them except when the population is very small in relation to the available resources.

Intraspecific Scramble Competition V/S Intraspecific Contest Competition

- Intraspecific contest competition encompasses a wide variety of different type of behavior. In some situations, animals may not compete directly for a specific resource, but indirectly for a social status or for territories.

Competition

- **Territories** are areas of land that an individual will defend against invaders. The possession of a territory guarantees access to certain resources, such as food, shelter, nesting sites, or a mate.
- Most social animals have ***Pecking Orders.*** These are social hierarchies in which low-ranking members defer to those of higher rank. Individuals of low status get out of the way when a higher ranking member of the group demands access to a resource such as food or a mate. Humans and many other species of primates are among those animals that compete for social status and, so indirectly for any scarce resources that such status might bring.
- Competition for territories that guarantee their owners access to shelter and food is common among higher animals.

Interspecific Competition

- Interspecific Competition is a competition between members of two or more different species for the same resource.
- Ecological theory states that two different species living in a single ecosystem cannot have identical niches.
- In other words, if individuals of two species compete intensely for the same resource, one species will always be more successful. The looser will, then be eliminated from the ecosystem or will be forced to change its niche requirements in some way.
- Several species coexist while competing strongly for the same resource. Example: Several species of warbles (birds) often feed on the same species of insects in the same part of a forest, but the different species forage for insects in different parts of trees, thereby reducing competition between them.

Interspecific Competition

- In general, in all ecosystems, the different species invariably partition the resources between them to reduce direct competition.
- Interspecific competition often restricts the abundance and distribution of natural populations.
- In almost all cases, competition between two species reduces population of both competitors; therefore it is tempting to say that one species would be "better off" if its competitors were eliminated. This is not always the case.

Predation

- This is an interaction in which certain individual eat others. Since all heterotrophs must eat to survive, predation is an integral part of any ecosystem.
- All consumers – herbivores and carnivores alike – can be considered to be predators. Predation is a major cause of mortality to most natural population.
- In many systems, predatory pressures either improve the health and vitality of a community of prey in a system.
- Even though predators kill individuals, predation may *increase* the number of prey species in an ecosystem.

Parasitism

- This is a special case of predation in which the predator is much smaller than the victim and obtains nourishment by consuming the tissue or food supply of a living organism known as a **host.**
- Just as predator – prey interactions are balanced in healthy ecosystems, parasite – host relationship have also become part of the balance of nature.

Commensalism

This is relationship in which one species benefits from an unaffected host. Several species of fish, clams, worms, and crabs live in the burrows of large sea worms and shrimp. They gain shelter and often eat their host's excess food or waste products but do not seem to affect their benefactors.

Symbiosis

- This is derived from the Greek for "living together", means a relationship between organisms that is beneficial to both. Each partner in a symbiosis is called a symbiont.
- There are two kinds of symbiosis. One, is called **mutualism**, is a necessary relationship – each organism dies without the other. The second, called **protocooperation**, is not necessary to either organisms, in the sense that each can survive without the other, but the interaction is beneficial to both. Both kinds of symbiosis are extremely important in nature.
- Symbiosis is a dynamic relationship that can change, sometimes rapidly, over a time. As an example, in many cases parasitism is a symbiosis that has become unstable. In other cases, parasitism evolves gradually into symbiosis.

Factors Affecting Regulation of Populations

- An organism can thrive only if all the essentials of life are available. For example, a plant may have adequate supplies of space, light, moisture, and most nutrients, but if one essential mineral is lacking, the organism will not survive.
- The ***Law of Limiting Factors*** states that the growth of a species is limited by resource that is least available in the ecosystem.
- Limiting factors can take many different forms - physical or biological.

Environmental Resistance – Physical Factors

- Shortage of Nutrients, Light, and space
- Climatic Factors
- Disasters

Environmental Resistance – Biological Factors

- Competition
- Predation
- Parasitism
- Commensalism
- Mutualism or Cooperation

Kinds of Interactions Among Species

	Effect[a]			Kinds of Interactions Among Species	
	Interaction	Species A	Species B	Result	Example
0	Neutralism	0	0	Neither Affects the other	
1	Competition	-	-	A and B Compete for the same resource; each has a negative effect on the other	Two hummingbird species competing for the same flower nectar
2	Inhibition	0	-	A inhibits B; A is unaffected	One species of bacterial in a cow's rumen releases a chemical that inhibits the other bacterium
3	Parasitism – Predation	+	-	A, the parasite or predator, benefits. A feeds on B, the host or prey, who there by suffers a direct negative effect.	Heartwirm in a reindeer
4	Symbiosis	+	+	A and B require each other to survive	Hummingbird and hummingbird flowers; some bacterial and reindeer
5	Commensalism	+	+	A requires B to survive; B is not affected significantly	Mites and hummingbird flowers
a					
0 = no effect; + = Positive effect on birth, growth or survival - = Negative effect on birth, growth or survival					

Summary

- Populations have a great capacity for rapid growth under appropriate environmental conditions, but this rarely occurs in nature.
- A population growing exponentially has a constant percent rate of increase; populations are capable of exponential growth, but this is rarely achieved in nature and can never be sustained indefinitely.
- The abundance and distribution of a species is ultimately limited by the availability of required resources. When a resource is in such short supply that it can limit population growth, it is called a limiting factor.
- The carrying capacity is the maximum population that can exist in a habitat or ecosystem over a long time without detrimental effects to either that population or to that habitat or ecosystem.
- A population has five major characteristics: a size; rates of birth; death and growth; and an age structure.

Summary

- The age structure of a population is the number of individuals of each age. The age structure can have a great effect on rates of birth, death, and population growth. Changes in the age structure can lead to changes in the impact of a population on its environment.
- There are often delays in the responses of populations to changes in the environment. These delays can lead to major environmental effects.
- No species can exist alone – each requires other species for its persistence.
- Species interact in five ways: commensalisms, symbiosis, parasitism – predation, competition, and inhibition.
- Two species that have exactly the same requirements can not coexist in a uniform environment. This is known as the competitive exclusion principle. Competing species coexist by using different aspects of a heterogeneous habitat.
- Where an organism lives in its habitat; what it does is its niche.

<u>End of Part 2</u>